Hopi Arsenic Mitigation Project (HAMP)

Design Update Summary Report

IHS Project Number PH 18-V31

Indian Health Service/Phoenix Area Office/Eastern Arizona District Office

19 October 2018

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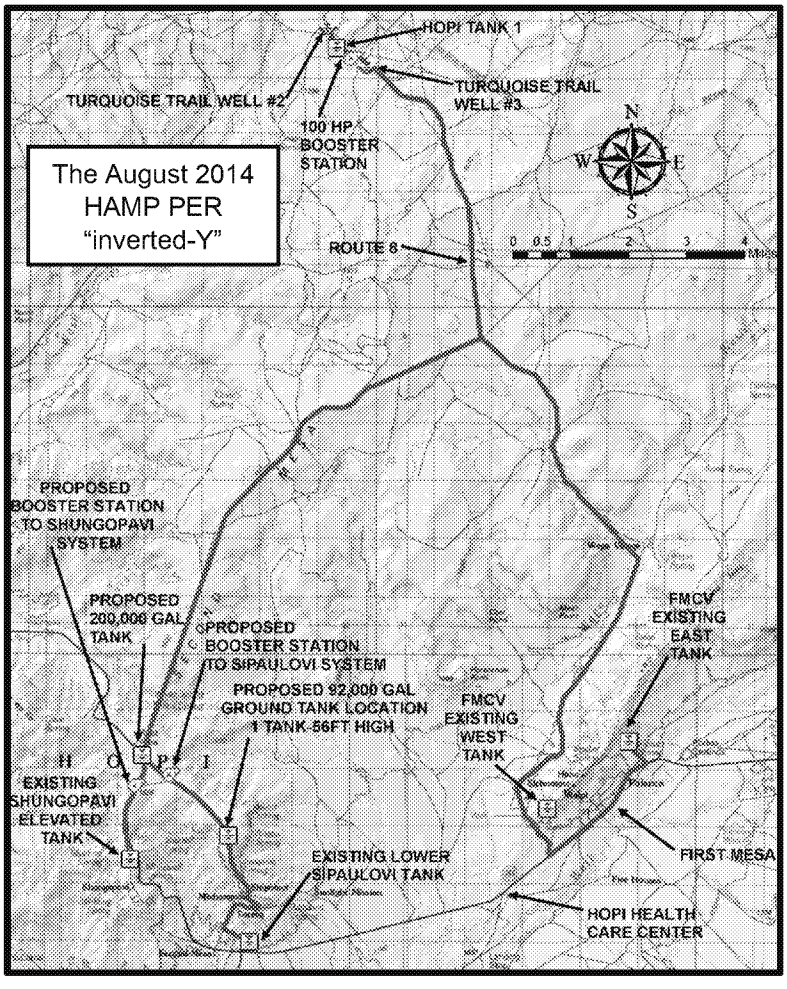
Background and Introduction

Eight (8) public water systems (PWS) in the First and Second Mesa areas of the Hopi Reservation do not comply, or struggle to comply, with the federal Safe Drinking Water Act (SDWA) maximum contaminant level (MCL) of 10 parts-per-billion (ppb) arsenic (As) in the product of their community water systems. For those PWSs, naturally occurring levels of As in existing water supply source wells range from 12 – 35 ppb. Four village water systems are currently in violation of the 10 ppb As MCL. One tribal PWS, a Bureau of Indian Affairs (BIA) PWS and two (2) Bureau of Indian Education (BIE) PWSs are able to comply intermittently with the As MCL by utilizing a variety of difficult and expensive to operate As-removal treatment systems.

The 2014 HAMP Preliminary Engineering Report (PER

In August of 2014 the Indian Health Service/Eastern Arizona District Office (IHS/EADO) published a Preliminary Engineering Report (PER) entitled: PRELIMINARY ENGINEERING REPORT FOR HOPI ARSENIC MITIGATION ALTERNATIVES, IHS Projects PH12-E73, PH11-E55, PH10-E37, PH08-T38, PH06-D33, PH04-S63.



The 2014 PER recommended that two (2) large-diameter, 2200-feet deep N-aquifer wells should serve as the dual-source for a regional water transmission system that would provide potable, SDWA-compliant water to the First and Second Mesa Hopi villages. Those wells, Turquoise Trail wells no. 2 and 3, were drilled in 2013 specifically for the purpose of serving the HAMP.

Turquoise Trail well no. 1 is an older and smaller well that was drilled further to the north to provide construction water for the Tawa'ovi community development site. That well would not be suitable as a HAMP water source.

The proposed 2014 PER system was to be configured as an "inverted-Y" with the source wells at the (top) base of the wye while the two arms of the wye supplied water to the FMCV and Second Mesa village utilities respectively. The project would include multiple water storage tanks (WST), two (2) pressure-boosting stations and several pressure reducing valve (PRV) vaults for water which would descend from Upper Sipaulovi/Mishongnovi down to Lower Sipaulovi/Mishongnovi.

The "inverted-Y" layout had initially been reviewed and approved by the Hopi Tribal Council in 2012, and then again in greater detail with publication of the 2014 HAMP PER. In August of 2014, un-funded cost estimate for the "inverted-Y" system ranged from $16M – $18M. Now, in October 2018, that cost is seen to be approximately $21.5M based on recent re-evaluation by the IHS. The 2014 "inverted-Y" plan was the IHS' initial engineered design plan for the HAMP.

Project Funding

As noted, the main purpose of the August 2014 HAMP PER was to serve as justification for a project funding request to the United States Department of Agriculture–Rural Development (USDA-RD) program. If successful, that request would have provided 75% of remaining un-funded HAMP capital costs as a direct grant to the Hopi Tribe and a 40-year low-interest loan to the tribe as financing for the remaining 25% of un-funded project costs. The need to repay a 25% loan over a 40-year period was not a preferred option among residents of the First and Second Mesa Hopi villages which would be participating in the HAMP water supply effort and which, as the local water consumers and utility ratepayers, would become the back-bone of the HAMP utility operations financial support effort.

Between 2014 and 2018, the Hopi Tribe sought to address compliance with USDA-RD financial audit standards that would allow the tribe to submit a grant/loan application to that agency. In June 2017, the Hopi Utility Corporation (HUC) was chartered by the Hopi Tribe with the intent that the HUC would formally pursue a USDA-RD grant/loan as an independent entity of the Hopi Tribe. In addition, it was stated that the HUC would be the operator of all HAMP-system infrastructure which was not a part of existing village utility infrastructure.

During that time, multiple meetings between the USDA-RD, the Hopi Tribe, the HUC, the United States Environmental Protection Agency (USEPA) and the IHS/EADO occurred. During those meetings, the USDA-RD expressed its support for village based As-removal treatment plants as opposed to a regional distribution system without the need for treatment. i.e. the HAMP concept, as was preferred by the Hopi Tribe, the USEPA and the IHS.

In June of 2017 an expansive written response to the IHS/EADO August 2014 PER document was received by the IHS/EADO from the USDA-RD. That response strongly implied that the USDA-RD would only be willing to provide HAMP funding if a project design shift would be made toward the USDA-RD preference for construction and operation of multiple As-removal water treatment plants in the First and Second Mesa villages. Prior to the USDA-RD response, the Hopi Tribal Chairman and the affected First and Second Mesa villages had officially stated their strongly-held preference for a regional water transmission/distribution system option, i.e. the HAMP which utilizes Turquoise Trail Wells source water without a need for As-removal treatment facilities to be operated by the First and Second Mesa village utility organizations.

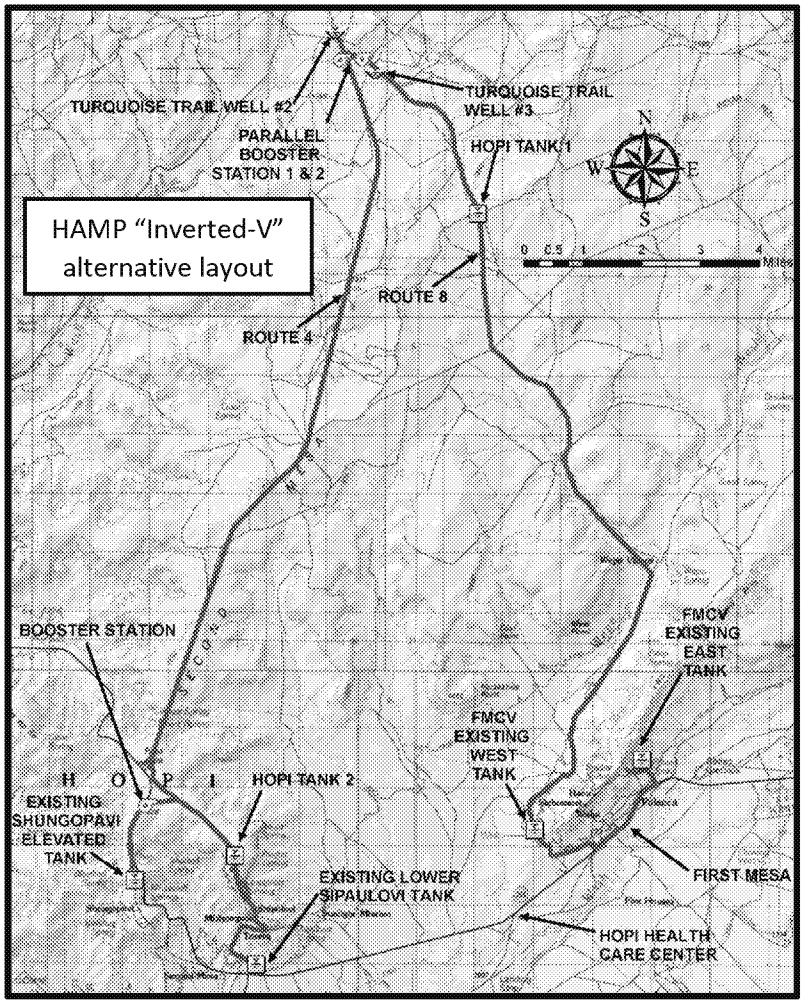
While attending a Hopi Tribal Council meeting on 25 April 2018, the IHS announced an allocation of $10M for the HAMP construction effort during FY 2018. Additionally, it was announced that the USEPA would fund an additional $4M over the next two-year period. The IHS FY2018 allocation was subsequently increased from $10M to $11M and EPA provided $3M of their $4M commitment in FY2018 as well. Current and future HAMP project funding is delineated in Project Summary PH 18-V31 which was signed on August 29, 2018 and awaits the signing of the associated Memorandum of Agreement which resides with the Hopi Tribal Council. Project Summary PH 18-V31 denotes the projected availability of an additional $4M in IHS and EPA funds that presumably would be distributed over a 2-3 year period if future agency budgets allow.

When coupled with approximately $1.1M committed by the Hopi Tribe (through the HUC) for electrical power main extensions to the Turquoise Trail wells, the IHS and EPA funding commitments as captured in Project Summary PH 18-V31 would meet the projected funding needs of the HAMP.

Design Options Analyses

Since the 25 April 2018 Hopi Tribal Council meeting, the IHS/EADO engineering staff, in consultation with HUC and Hopi HAMP village personnel, had further scrutinized the proposed 2014 PER "inverted-Y" HAMP layout from a hydraulic, economic, constructability and cultural compatibility perspective. That scrutiny revealed construction and operational pumping cost concerns that could be mitigated through the consideration of alternative pipeline routing designs. On 10 July 2018, the IHS/EADO released a 116-page DRAFT document entitled 10% Design Report for the Hopi Arsenic Mitigation Project – IHS Project Number PH 18-V31.

The 10% design report document was significant because it described a variation of the "inverted-Y" which is referred to as the "inverted-V" while also presenting a third design alternative which is referred to as the "J-hook".

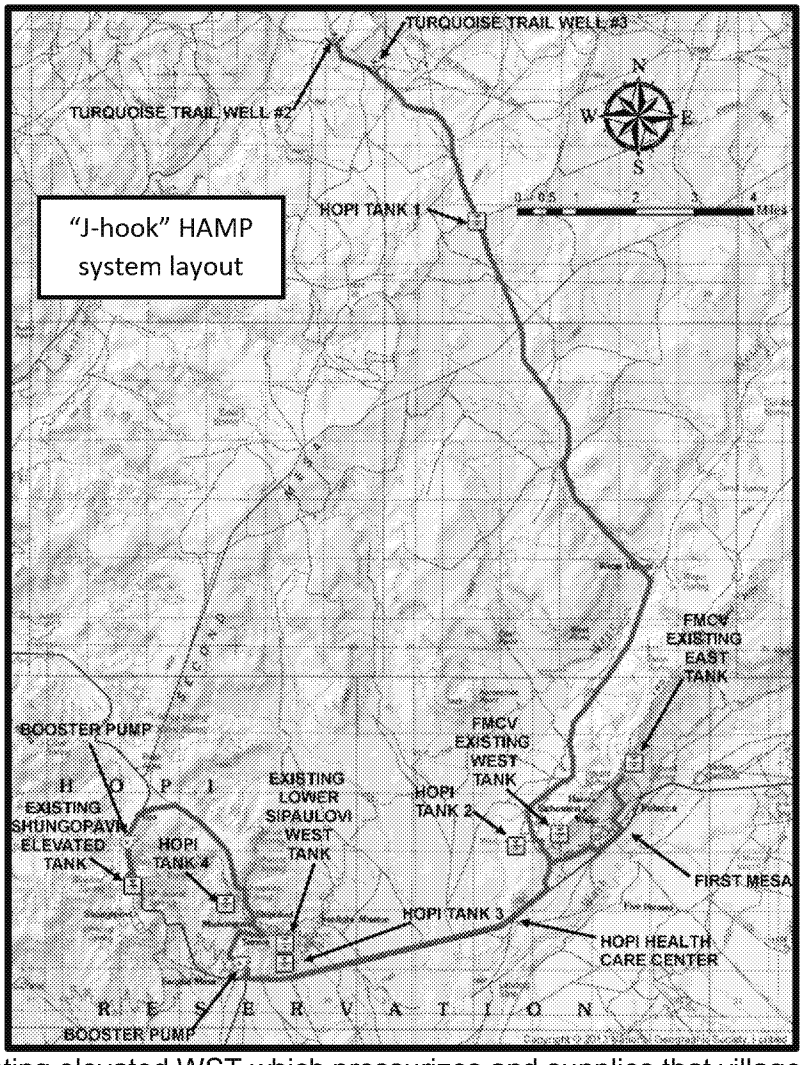


The "inverted-V" layout would utilize two separate pressure boosting systems in a side-by-side configuration to pump water from the Turquoise Trail wells in two directions through two separate transmission mains. One of the lines would trend from the pressure boosting facility SSW along Route 4 then up to Second Mesa, Shungopavi and Upper Sipaulovi/Mishongnovi. A booster pumping station would also be sited near Shungopavi to fill the elevated WST in that community. The other branching line would send water SSE to a WST along Route 8 from where water would then be able flow by gravity directly to the FMCV/Polacca water system.

The "inverted-V" system would require approximately 16,000-feet of additional pipeline compared to the "inverted-Y" system and much of that pipeline would have to be installed in very dense sandstone and hard granite which presented a high likelihood that the cost per foot of pipeline installation would increase. Thus, the estimated cost of the "inverted-V" plan could be excessive and may require that significant construction-cost and scheduling risks would need to be assumed.

The previously referenced "J-hook" plan resembles a leftward facing hook that is initially aligned SSE along Route 8 from the Turquoise Trail wells to the west side of First Mesa from where it then arcs WSW along Hwy AZ 264 to Lower Sipaulovi/Mishongnovi before curving sharply northward through a booster station to Toreva and the top of Second Mesa where it would supply water to Upper Sipaulovi/Mishongnovi and all of Shungopovi.

The "J-hook" would pump water from Turquoise Trail Well Nos. 1 and 2 to Hopi WST No.1 adjacent to Route 8. From Hopi WST No.1, water would flow by gravity through a transmission main to pressurize and supply the FMCV/Polacca system. A new Hopi WST No. 2 would be constructed adjacent to the existing FMCV West WST which will soon be replaced under IHS Project No. PH 15-U76. The transmission main would then extend WSW along Hwy AZ 264 to Lower Sipaulovi/Mishongnovi where it would fill the existing Lower Sipaulovi/Mishongnovi WST and a new Hopi WST No. 3. That new WST would be constructed adjacent to the existing Sipaulovi WST.



The new WSTs of the "J-hook" layout would provide additional storage and system redundancy. In addition, the new Hopi WST No. 3 in Sipaulovi would serve as the "positive-head" for a pressure boosting system which would be constructed next to that WST to pump water up through Toriva to Upper Sipaulovi/Mishongnovi and the adjacent Second Mesa areas. A second booster station near Shungopavi would fill the existing elevated WST which pressurizes and supplies that village water distribution system.

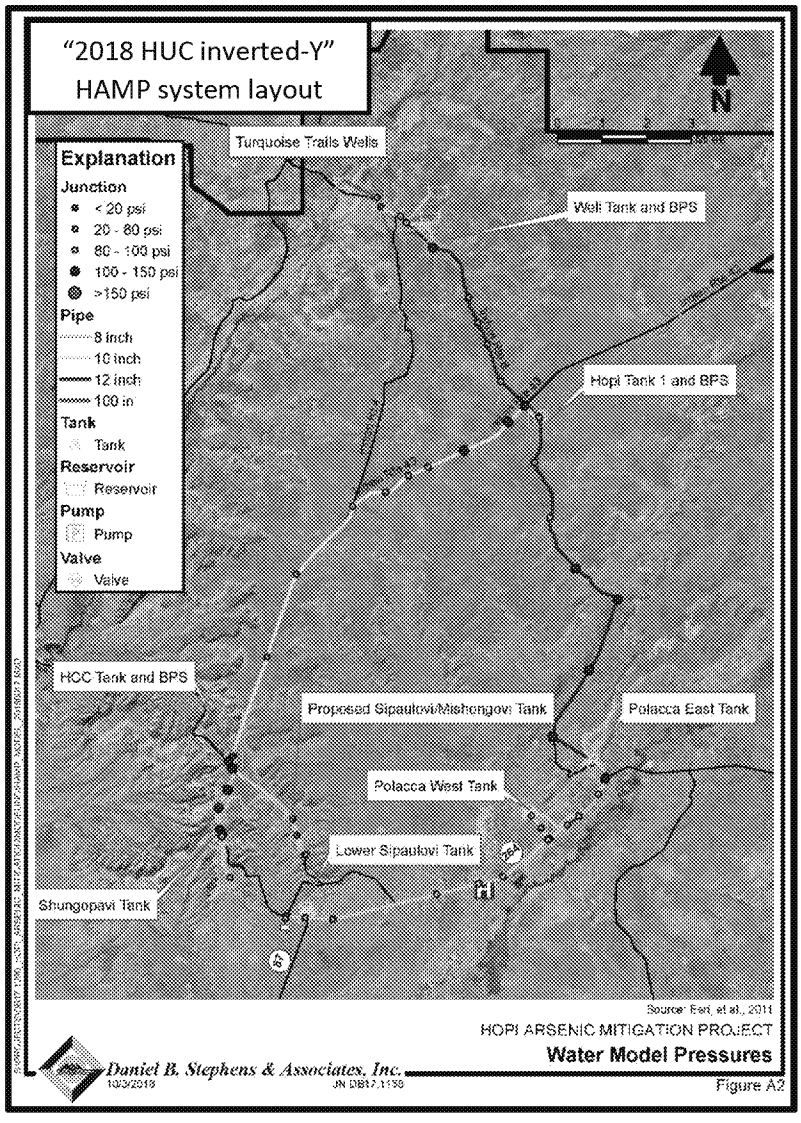
The "J-hook" system is designed to maintain hydraulic separation between the HUC/HAMP transmission main piping and the distribution systems of each individual village water system. In that manner, if a water quality problem should occur in one village distribution system, that problem would not be transferred to another village system on the same overall HUC/HAMP water transmission system.

With each of the design layout options, the Hopi Cultural Center PWS would be positioned to receive HAMP water from either the Shungopavi village system or directly from the HUC/HAMP transmission main.

A fourth design layout was recently proposed which can be referred to as the "2018 HUC inverted-Y" alternative. That system proposal was development by an engineering consultant under a

contract with the HUC. The "2018 HUC inverted-Y" alternative would utilize four (4) booster stations and supply water along a route which is similar to the 2014 PER "inverted-Y".

One of the proposed booster stations, which would pump water to the Shungopavi and Upper Sipaulovi/Mishongnovi water systems, would be sited where there is currently no grid-power from APS or NTUA. The HUC has suggested that solar photo-voltaic power with large industrial-size batteries and a propane-fueled back-up generator could be utilized to power the pumps at that pressure-booster station location. Alternatively, grid-power could be extended from the Turquoise Trail well site to power the pressure boosting pump facility. A written cost estimate for providing power to the pressure booster site has not been provided.



The "2018 HUC inverted-Y" plan also proposes that an under-ground pipeline bore be completed from the north-side of the First Mesa, upwards and through the Mesa, in order to directly supply piped water to the FMCV East WST. A written cost estimate to conduct sub-surface boring for that pipeline has not been provided.

Water from the FMCV East WST would then pressurize and supply the four (4) existing pressure zones of the FMCV/Polacca distribution system just as it currently does. Through that process, the FMCV West WST would also be filled.

From the FMCV West WST, water would then flow WSW by gravity along HWY AZ 264 in order to pressurize and supply what would then be classified as the Lower Sipaulovi/Mishongnovi consecutive water distribution system.

Assumptions, Observations and Constraints

A comparison of the HAMP system layout options reveals the following list of design option pros and cons.

1. Regardless of the pipeline design layout selection, the previously referenced $1.1M funding commitment from the Hopi Tribe/HUC for the extension of NTUA electrical power to the Turquoise Trail wells is a critical component of the overall HAMP funding scenario. Without a functional water source, i.e. power having been extended to the Turquoise Trail Wells, pipeline hydraulic pressure-testing and WST leak-testing will not be possible during the project construction phase. Thus, the Turquoise Trail wells must be energized and functional before pipelines and WSTs can be constructed and verified for their integrity.
2. The most recent IHS/EADO construction cost estimate for the 2014 PER "inverted-Y" design (exclusive of the well-power extension costs) is approximately $21.5M.
3. The estimated additional capital construction cost differential between the 2014 PER "inverted-Y" layout with respect to committed project funding is approximately $2.5M. That differential has not been identified to be met with future IHS or USEPA funding. For the 2014 PER "inverted-Y" layout to be selected/designated for construction as the HAMP solution, the Hopi Tribe would need to identify and appropriate the listed un-funded project capital cost amount.
4. The most recent IHS/EADO construction cost estimate for the "inverted-V" design (exclusive of the well-power extension costs) is approximately $21.0M.
5. The estimated additional capital construction cost differential between the "inverted-V" layout with respect to committed project funding is approximately $2.0M. That differential has not been identified to be met with future IHS or USEPA funding. For the "inverted-V" layout to be selected/designated for construction as the HAMP solution, the Hopi Tribe would need to identify and appropriate the listed un-funded project capital cost amount.
6. The most recent estimated construction cost for the "J-hook" design (exclusive of the well-power extension costs) is approximately $19.0M.
7. There is no estimated cost differential between the "J-hook" layout with respect to identified available project funding.
8. Per the DB Stevens & Associates 10 October 2018 Technical Memorandum entitled Hopi Arsenic Mitigation Project Regional Water System Conceptual Evaluation, the construction cost estimate for the "2018 HUC inverted-Y" design (exclusive of the well-power extension costs) is approximately $20.3M
9. The most recent IHS/EADO construction cost estimate for the "2018 HUC inverted-Y" design (exclusive of the well-power extension costs) is approximately $21.8M. That higher estimated cost is a result of adjusting several key project cost line items to meet known needs such as increased unit-costs for higher pressure-rated pipe in specific areas, the inclusion of previously omitted system blow-off/flushing valves, doubling the construction price for WSTs from $1 per capacity-gallon to at $2 per capacity-gallon etc.
10. According to the DB Stevens & Associates 10 October 2018 Technical Memorandum entitled Hopi Arsenic Mitigation Project Regional Water System Conceptual Evaluation, The estimated additional capital construction cost differential between the "2018 HUC inverted-Y" layout with respect to committed project funding is approximately $1.3M. The estimated additional capital construction cost differential between the IHS/EADO construction cost estimate for the "2018 HUC inverted-Y" layout with respect to committed project funding is approximately $2.8M. Neither of those capital construction cost have been identified to be met with future IHS or USEPA funding. For the "2018 HUC inverted-Y" layout to be

selected/designated for construction as the HAMP solution, the Hopi Tribe would need to identify and appropriate the listed un-funded project capital cost amount(s).

11. It is understood that the estimated "2018 HUC inverted-Y" capital cost differential as derived by the DB Stevens and Associates may be subject to revision pending the receipt of written cost estimates for the provision of an electrical power source to the isolated pressure booster station and for the cost of conducting a pipeline bore upwards through the First Mesa to the FMCV West WST.

    Currently, the estimated cost of extending power from the future NTUA Turquoise Trail Wells power drop to the proposed booster station site is listed as $50,000. However, that power extension distance appears to be approximately 5.5 miles and thus the actual cost is likely to be higher.

12. In contrast to the 2014 PER "inverted-Y" concept, the "J-hook", the "2018 HUC inverted-Y" and the "inverted-V" system layouts both represent appreciable electrical pumping cost savings of at least $19,000/year beginning with system start-up. Such savings are possible because only the water which is used by the utility systems on Upper-Second Mesa, about 30% of total HAMP well production, will need to be pumped up to those higher elevations. Those savings are likely to increase over time as community water demands and the cost of power ($/kW) increase into the future.

13. The "J-hook" system eliminates the need for a series of pressure reducing valves (PRV) between Upper and Lower Sipaulovi/Mishongnovi. PRVs are known to be high maintenance installations which are critical to long-term system operational stability. The failure of a PRV could produce downstream main line breaks and potentially dangerous pressures at lower elevations. The elimination of PRV's further simplifies the operation of the regional water system and reduces life cycle costs.

14. By eliminating the need for PRV installations, the "J-hook" system will instead utilize a pressure booster station to pump water up to the Second Mesa villages from Lower Sipaulovi. That pump facility would operate in excess of 273-psi and the system piping between Upper and Lower Sipaulovi would be holding those pressures at the lower elevations of that hydraulic zone. The maximum pumping pressure generated by the booster station would be 287-psi.

15. In contrast to the "J-hook" design, the "inverted-V" layout eliminates the need for a pressure booster station to be installed in Lower Sipaulovi. However, the "inverted-V" layout would require a booster station to be constructed near the Turquoise Trail wells. That booster station would operate at approximately 240-psi. The maximum pumping pressure generated by the booster station would be 250-psi.

16. The "J-hook" design provides operational redundancy and facilitates O&M by siting two (2) HAMP-system WSTs where they can be manually backed-up by existing village WSTs. One of those WSTs would be next to the FMCV West WST and the other would be next to the Lower Sipaulovi/Mishongnovi WST.

17. While the "J-hook" system is more linear than the "inverted V" layout, it does not allow water to enter a village utility piping system and then transfer later to the distribution system of another village utility. Thus, all water from the Turquoise Trail HAMP wells will remain in HAMP transmission pipelines until it is automatically transferred directly into village utility WSTs from which it cannot flow back into the HAMP piping network. This configuration allows the HUC to serve as a direct wholesale water provider. The USEPA-R9 could subsequently be classified each of the HAMP village PWSs as "consecutive" to the HUC/HAMP public water system, but not to each other.

18. Both layout options provide full capacity to meet estimated 40-year water-system demands. Several key design modifications will need to be specified if the previously referenced BIA

and BIE facilities elect to become customers of the HUC by direct connections to the HAMP system as proposed. Those modifications include increasing the system hydraulic capacity with the addition of an additional source well, an additional WST to serve as a transmission main supply buffer and larger transmission piping in several key areas between the Turquoise Trail Wells and the FMCV.

19. In contrast to the "inverted-V", the "J-hook" system-layout would eliminate approximately 45,000-feet of pipeline that would otherwise need to be installed in "sandstone" which is known to be expensive on a "per-foot" basis when contrasted with excavation in less consolidated strata/soils. It is also likely that several more months of construction time would be required for that more difficult pipeline installation.

Summary Table of Estimated Layout Option Construction Costs

System Layout Option	Estimated Approximate 2018 Capital Cost	Estimated Approximate Un-Funded Capital Cost
2014 PER Inverted-Y	$21.5M	$2.5M
Inverted-V	$21.0M	$2.0M
J-Hook	$19.0M	$0
2018 HUC Inverted-Y	$20.3M (DB Stevens & Associates)	$1.3M
2018 HUC Inverted-Y	$21.8M (IHS/EADO)	$2.8M